LA-UR-21-29396
Approved for public release; distribution is unlimited.

Title: Determination of the Eutectic Composition in NaCl + MgCl2

Author(s): Parker, Stephen Scott
Mann, Shane Collin
Jackson, Jay Matthew
Monreal, Marisa Jennifer

Intended for: Group meeting update slides

Issued: 2021-09-23

Determination of the Eutectic Composition in NaCl + MgCl2

Scott Parker, Shane Mann, Matt Jackson, Marisa Monreal

The available literature:

References:

[1] A. Kisza, J. Kazmierczak, B. Borresen, G. M. Haarberg, R. Tunold J. Electrochem. Soc., Vol 144, No 5 (1997).
[2] J. Wang, C. Zhang, Z. Li, H. Zhou, J. He, J. Yu, Sol. Energy Mater. Sol. Cells Vol 164 146-155 (2017).
[3] M. Mohamedi ECS Proceedings Vol 1996-7 189 (1996).
[4] O. Benes, R. J. M. Konings J. Nucl. Mater. Vol 375 202-208 (2008).
[5] P. Chartrand, A. D. Pelton, Met. Mater. Trans. A Vol 32A 1361 2001
[6] T. Xu, X. Li, L. Guo, F. Wang, Z. Tang, Sol. Energy Vol 209 568-575 (2020).

*Papers which study “NaCl-MgCl2 Eutectic” but do not state a composition:

A. Kisza, J. Kazmierczak, B. Borresen, G. M. Haarberg, R. Tunold J. Electrochem. Soc., Vol 144, No 5 (1997).
B. Liu, et al, Sol. Energy Mater. Sol. Cells Vol 170 77-86 (2017).
D. E. Neil et al, J. Chem. Eng. Data Vol 10, No. 1, (1965).
L. Guo, et al, Corros. Sci. Vol 166 108473 (2020).
O. Benes, R. J. M. Konings J. Nucl. Mater. Vol 375 202-208 (2008).
P. Chartrand, A. D. Pelton, Met. Mater. Trans. A Vol 32A 1361 2001

Source: [1] A. Kisza, J. Kazmierczak, B. Borresen, G. M. Haarberg, R. Tunold J. Electrochem. Soc., Vol 144, No 5 (1997)

Eutectic composition is not stated. Graphically, it is assumed to be ~41%, with an associated melt point of 450 °C.

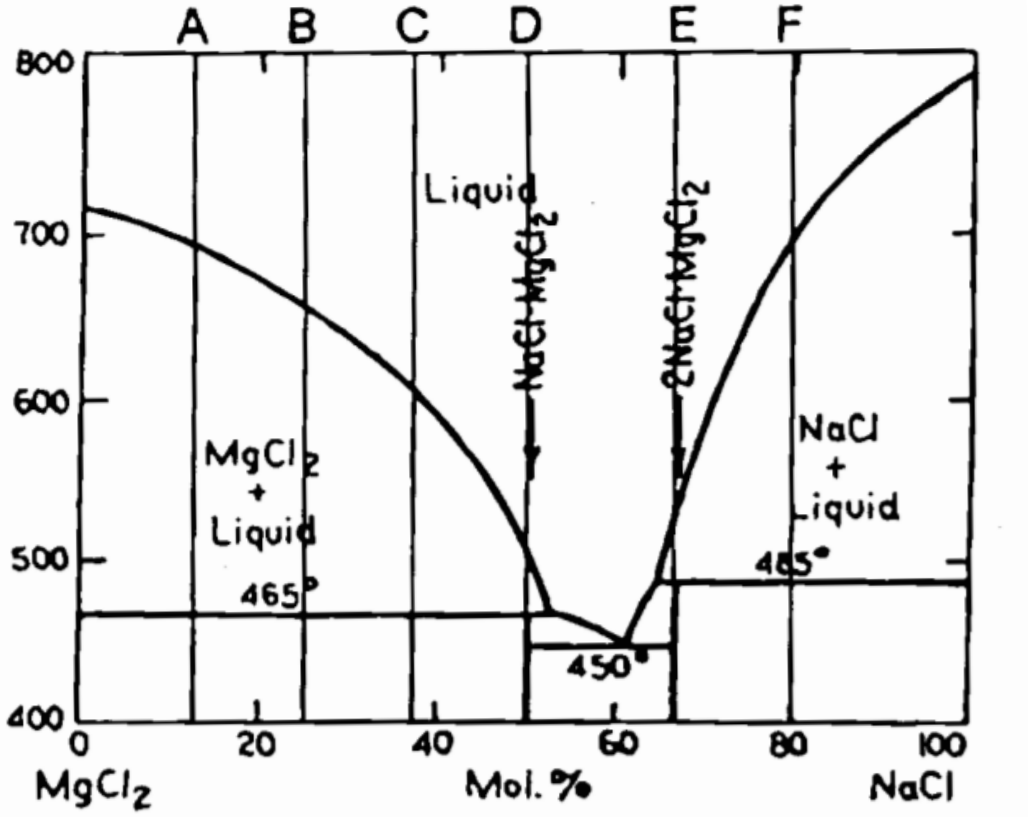


Fig. 2. The $MgCl_2$-NaCl phase diagram with the compositions of the melts studied.

Source: [5] P. Chartrand, A. D. Pelton, Met. Mater. Trans. A Vol 32A 1361 2001

Eutectic composition is not stated. It is approximated graphically as 0.41 mol fraction MgCl2. A calculated eutectic temperature of 459 °C is stated, however the authors note that the experimental values fall between 430 °C and 450 °C.

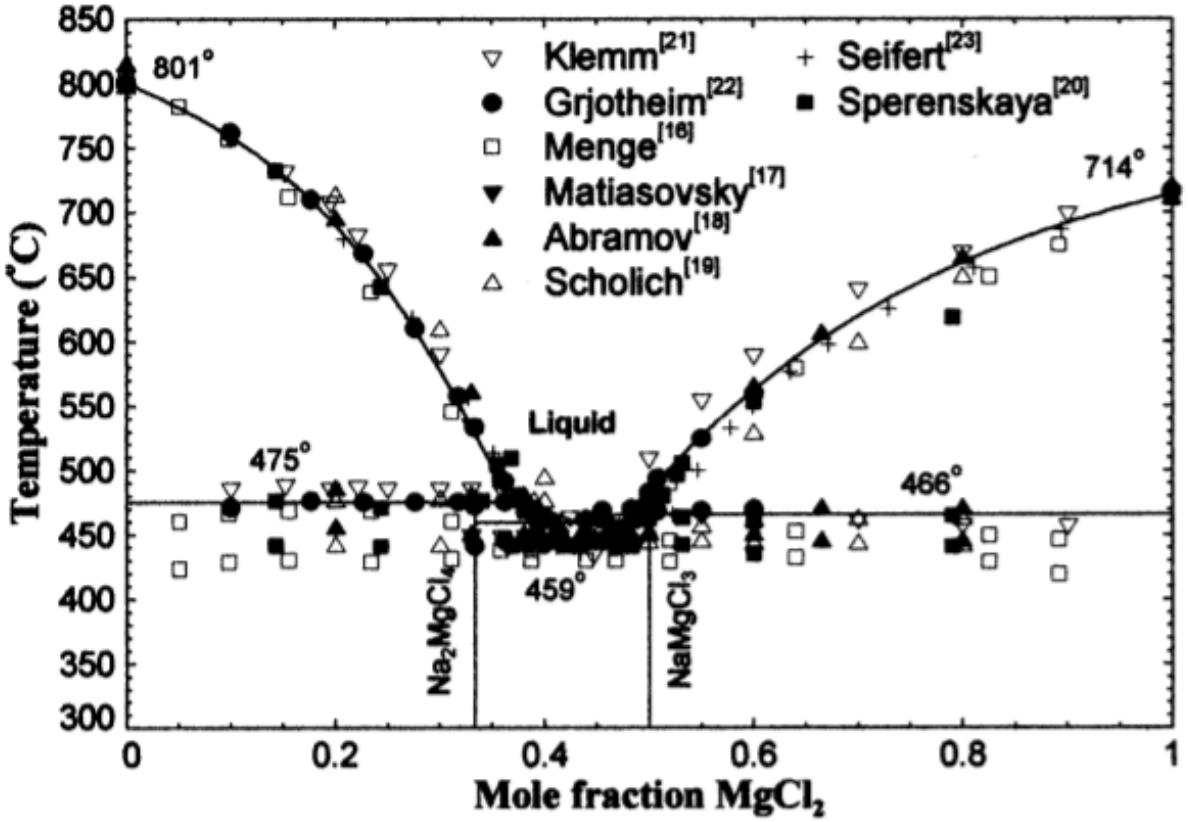


Fig. 5—NaCl-$MgCl_2$ system: calculated phase diagram.

Available Data

Source: [2] J. Wang, C. Zhang, Z. Li, H. Zhou, J. He, J. Yu, Sol. Energy Mater. Sol. Cells Vol 164 146-155 (2017).

Stated eutectic is NaCl-52wt % $MgCl_2$ (i.e. 39.94 mol % $MgCl_2$), with an associated melt point of 718 K (444.9 °C), and an enthalpy of fusion of 430 J/g.

Source: [3] M. Mohamedi ECS Proceedings Vol 1996-7 189 (1996)

Stated eutectic is NaCl-41.5 mol% $MgCl_2$ with an associated melt point of 445 °C.

Source: [4] O. Benes, R. J. M. Konings J. Nucl. Mater. Vol 375 202-208 (2008).

The eutectic composition is not stated, but the melt point is states to be 732 K (458.9 °C).
Interestingly, they state "*Because the simple eutectic systems were published earlier and are very well reproduced it is not necessary to show their figures in this work*." Unfortunately, the work they refer to is not cited, nor is it apparently published elsewhere.

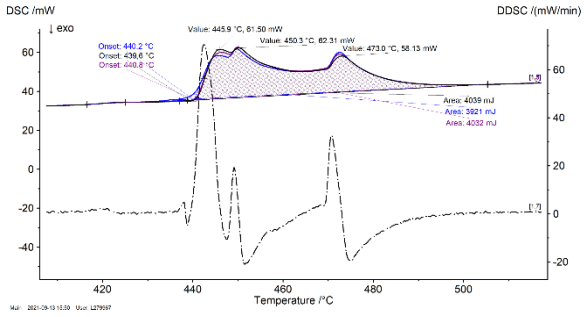
Source: [6] T. Xu, X. Li, L. Guo, F. Wang, Z. Tang, Sol. Energy Vol 209 568-575 (2020).

Stated eutectic is NaCl-42 mol% $MgCl_2$ with an associated melt point (extrapolated onset) of 710 K (436.9 °C) and enthalpy of fusion of 269.7 J/g (experimental) and 268.16 J/g (simulated).

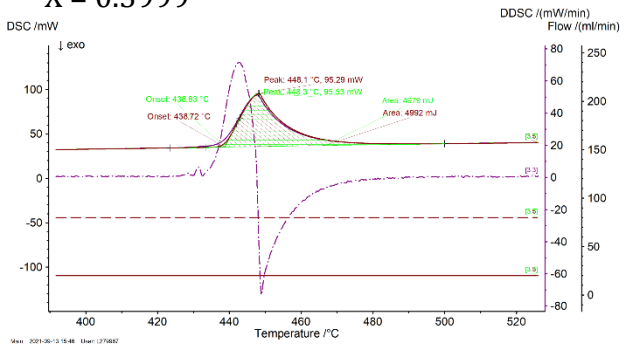
Recent Work

X = Mol Fraction $MgCl_2$

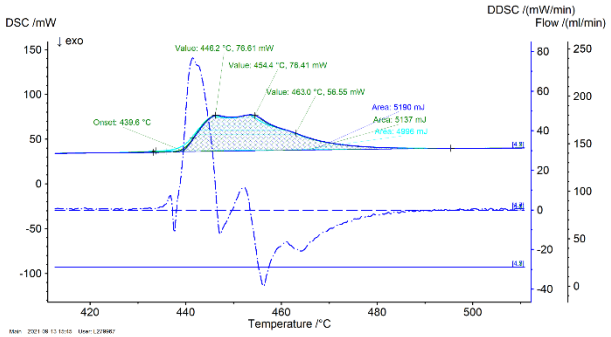
X = 0.4326



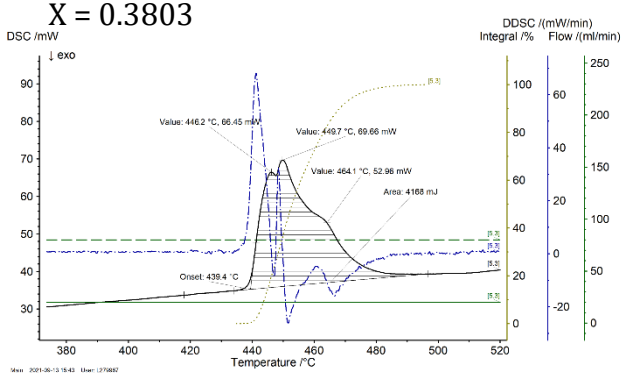
X = 0.3999

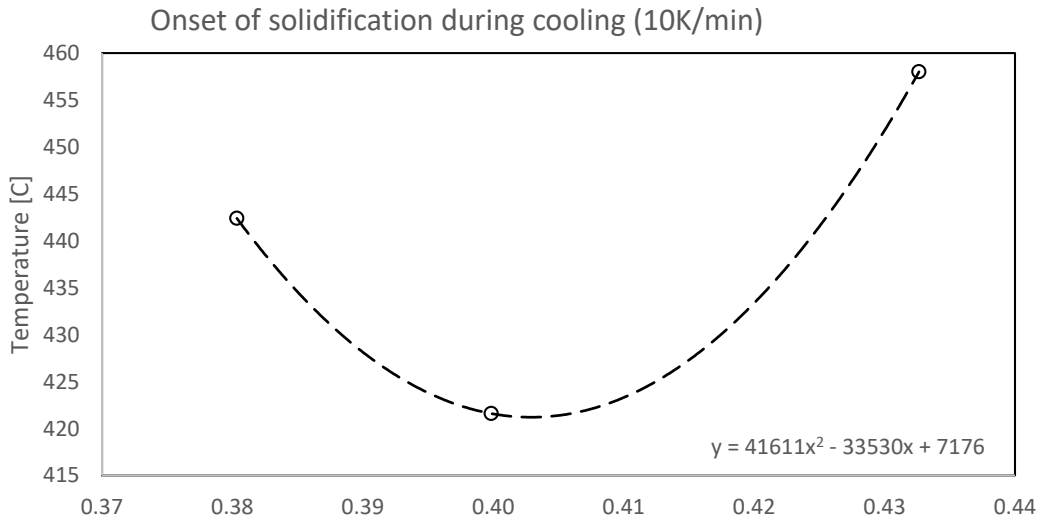


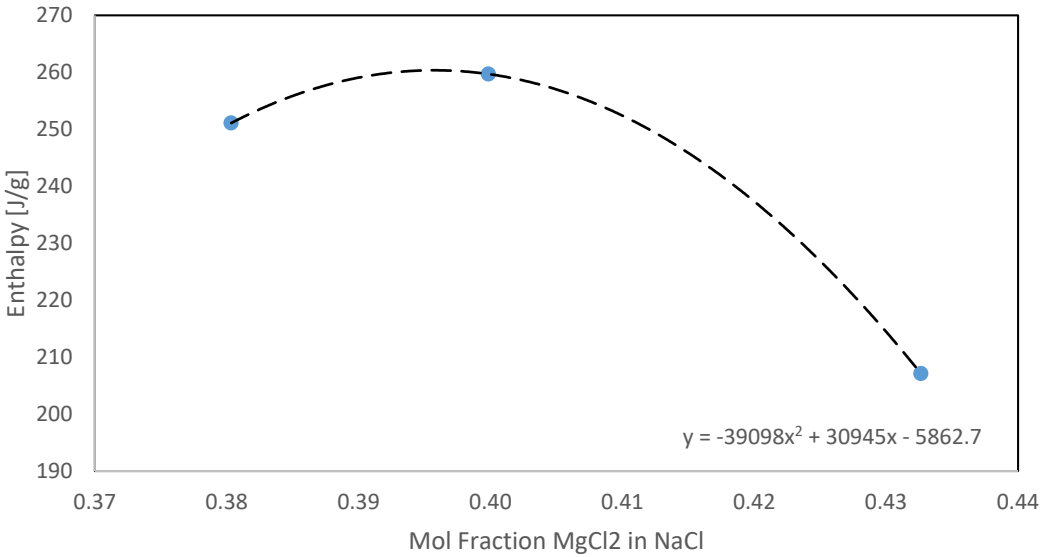
X = 0.4700



X = 0.3803







- From melt onset (estrapolated onset) of 4 compositions, $\mathbf{T_{eutectic} = 439.5}$
- From minimization of onset during cooling at 10K/min, the eutectic composition is **0.4029** mol fraction $MgCl_2$ in NaCl, and the enthalpy of fusion is **260 J/g**

Summary

Reference	Mol fraction $MgCl_2$	$T_{eutectic}$ [C]	Enthalpy of Fusion [J/g]
1*	0.41	450	-
2	.3994	444.9	430
3	.415	445	-
4*	0.41	448.9	-
5*	0.41	459	-
6	0.42	436.9	269.7
Average	0.41	447.5	-
2 X STDEV	0.0124	13.4	-
This Work	0.4029	439.5 ± 0.5	260 ± 6

*Eutectic composition is estimated graphically